Трансформация экосистем
Ecosystem Transformation

ISSN 2619-094X Print
ISSN 2619-0931 Online
www.ecosysttrans.com

Article

Characteristics of coenopopulations of European feather grass *Stipa pennata* L. in the South Ural State Nature Reserve

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Received: 12.05.2022
Revised: 01.06.2022
Accepted: 22.06.2022
Published online: 29.12.2022

DOI: 10.23859/estr-220512
UDC 58.009

Translated by D.M. Martynova

Abstract. The population characteristic of the steppe species *Stipa pennata*, rare for the South Ural State Nature Reserve, is given. Two coenopopulations (CP) of European feather grass have been analyzed in the western part of the reserve. The ecotope conditions affected the linear parameters of plants significantly. The weather conditions of the year predetermined the height of the generative shoot with a panicle and the leaf length. The maximum linear parameters have been noted for the plants of CP-2, located in a relatively shaded area with a higher projective cover of the herbaceous and shrub layers. High values of quantitative parameters have been noted in CP-1, which occupied more arid area. The influence of weather conditions on the phenological rhythms of plants are obvious: the acceleration of growth and development in dry years and the slowdown of these processes in the rainy period. The ontogenetic structure of coenopopulations and their demographic indicators are analyzed and presented. Age structure of coenopopulations of S. pennata has a right-shifted unimodal spectrum with a predominance of middle-aged plants. The total population density varies from 4.1 to 6.4 ind./m^2. The age and effectiveness of both populations testify they are young.

Key words: mountainous Urals, European feather grass, steppe communities, long-term dynamics, demographic structure, population density

To cite this article. Yusupova, O.V. et al., 2023. Characteristics of coenopopulations of European feather grass *Stipa pennata* L. in the South Ural State Nature Reserve. *Ecosystem Transformation* **6** (1), 25–38. https://doi.org/10.23859/estr-220512

Научная статья

К характеристике ценопопуляций *Stipa pennata* L. в Южно-Уральском заповеднике

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Поступила в редакцию: 12.05.2022
Доработана: 01.06.2022
Принята к печати: 22.06.2022
Опубликована онлайн: 29.12.2022

DOI: 10.23859/estr-220512
УДК 58.009

Аннотация. Приведена популяционная характеристика редкого для Южно-Уральского заповедника степного вида *Stipa pennata*. Проанализированы две ценопопуляции, произрастающие в западной части заповедника. Выявлено более высокое в процентном отношении воздействие условий экотопа на линейные параметры растений. Влияние фактора погодных условий года в значительной степени отмечено для высоты генеративного побега с метелкой и длины листа. Максимальные значения линейных параметров отмечены для ЦП-2, расположенной на относительно затененном участке с более высоким проективным покрытием травянистого и кустарникового ярусов. Высокие значения количественных параметров отмечены в ЦП-1, занимающей более сухой участок. Показано влияние погодных условий на фенологические ритмы растений: ускорение роста и развитие в засушливые годы и замедление этих процессов в дождливый период. Охарактеризована онтогенетическая структура ценопопуляций и приведены их демографические показатели. Возрастная структура ценопопуляций *S. pennata* имеет правосторонний одновершинный тип спектра с преобладанием средневозрастных растений. Общая плотность варьирует от 4.1 до 6.4 экз./м^2. Оценка возрастности и эффективности обеих популяций показала, что они являются молодыми.

Ключевые слова: горный Урал, ковыль перистый, остепненные сообщества, многолетняя динамика, демографическая структура, плотность

Для цитирования. Юсупова, О.В. и др., 2023. К характеристике ценопопуляций *Stipa pennata* L. в Южно-Уральском заповеднике. *Трансформация экосистем* **6** (1), 25–38. https://doi.org/10.23859/estr-220512

Introduction

Analyzing the distribution of rare plant species and assessing current state of their populations are fundamental stages in the study of the flora diversity of key areas, since these populations are the natural historical and evolutionary unit of a species existence, as well as an important criterion in planning human environmental activities (Timofeev-Resovsky et al., 1973). In the western part of the South Ural State Nature Reserve, on steep rocky slopes along the rivers, there are extrazonal xerophytic communities, in which European feather grass *Stipa pennata* L. is found. The state of two coenopopulations located on the western border of the reserve has been assessed for a number of years (Yusupova and Abramova, 2016).

European feather grass *Stipa pennata* L. (Poaceae) is a steppe dense turf herbaceous polycarpic grass, very decorative in the fruiting phase, 30–100 cm high, xerophyte, mesotroph, heliophyte with intra-sneath shoots (Fig. 1). Leaves are 0.5–2.0 mm wide, rolled lengthwise, rarely flat, shortly pointed at the apex, in young leaves with a brush of hairs up to 3 mm long; ligule 0.7–3.0 mm long; sneath naked or ciliated. The inflorescence is a panicle 3–5 cm long, compressed, carrying 6–20 spikelets. Spikelets are whitish; glumes 3–5 cm long, long-pointed; lemmas (15)16–17(21) mm long, completely below, and above with 7 rows of hairs, with an awn 25–35 cm long, awn bent, naked in the lower twisted part of chestnut color, pinnate above, with hairs about 5 mm long. Flowering in April–May, fruiting in May–June. The fruits are grains, they propagate. Self-seeding. Resistant in culture (Lomonosova, 1990; Serikova et al., 2013).

European feather grass is a European-Middle Siberian-Old Mediterranean species. In Russia, it is distributed in the south of the European part and in the south of Siberia. It grows in the steppes, in steppe meadows and clearings, on outcrops of chalk and limestone. In the Republic of Bashkortostan, it grows mainly in the steppe and forest-steppe zones; it is extremely rare in the mountain-forest zone (Kucherov et al., 1987; Opredelitel..., 1988). In the mountain-forest zone of the South Urals, *S. pennata* is probably a relic of one of the post-glacial eras, when the steppe vegetation was widespread. Currently, the areas of its natural growth are steadily declining in the region. *S. pennata* is included into the Red Data Book of the Russian Federation (2008), as well as into the Red Data Books of the subjects of Russia, including the Republic of Bashkortostan (2021) and the Chelyabinsk Region (2017).

The study aims to assess the current state of coenopopulations of *S. pennata* in the South Ural State Nature Reserve based on the analysis of morphometric characters and the features of the demographic structure of populations in different years.

Materials and methods

The studies have been carried out in the western part of the South Ural Nature Reserve (SUNR, quarters nos. 112 and 113 of the Yamashtinsky District Forestry), belonging to the region of broad-leaved-dark coniferous forests of the Southern Urals (Gorichev, 2016). The relief of the region is low-mountainous with wide longitudinal and narrow transverse valleys of mountain rivers. The climate is temperate continental. According to the nearest Inzerskaya meteorological station, the average annual air temperature is 1.2 °C, the average monthly temperature in January is −15.8 °C, in July, +17.0 °C, the annual precipitation is 667 mm, the growing season lasts for 164 days, the frost-free period is 107 days, the sum temperatures above 10 °C reaches 1800 °C (Gorichev, 2008). In general, the overall climate of the region is much humid and cool than the climate of the steppe zone, where the main range of the species is located. However, there are separate local ecotopes (rocks and steep southern slopes of river valleys), where extreme mesoclimatic and edaphic conditions contribute to the survival of European feather grass in conditions of weak competition from other species.

Observations have been carried out in 2015–2018 and 2021 for two coenopopulations (CP). CP-1 grows on the rocks of the right bank of the Malyi Inzer River (quarter no. 112), known to the local population as the Bashkir Rock (Fig. 1**A**). CP-2 grows on the rocky slope of the spur of the Malyi Yamantau Ridge, facing the valley of the Malyi Inzer River (quarter no. 113) (Fig. 1**B**).

The influence of weather conditions on early flowering plants is more pronounced during their active growth and flowering, mainly in May–June. According to our observations, *S. pennata* flowers at different times depending on weather conditions. Dates of the onset of phenological phases and some meteorological indicators for 2015–2021 are given in Table 1.

When comparing the meteorological conditions of the growing seasons, some certain regularities were observed. In terms of the number of rainy days, the seasons with the maximum precipitation were 2018, 2017 and 2015; in 2015 and 2017, May was the wettest. The season of 2016 was relatively warm and dry, 2017, the coolest. May of 2021 was hot and dry, with no precipitation throughout the growing season. The largest number of frosty days during the growing season has been noted in 2017, the lowest, in 2015 and 2021.

The study of morphometry in natural conditions has been carried out according to the method of V.N. Golubeva (1962) on 25 middle-aged individuals in each *S. pennata* coenopopulation. Observations and measurements have been carried out annually in the phase of the final flowering, during the period when

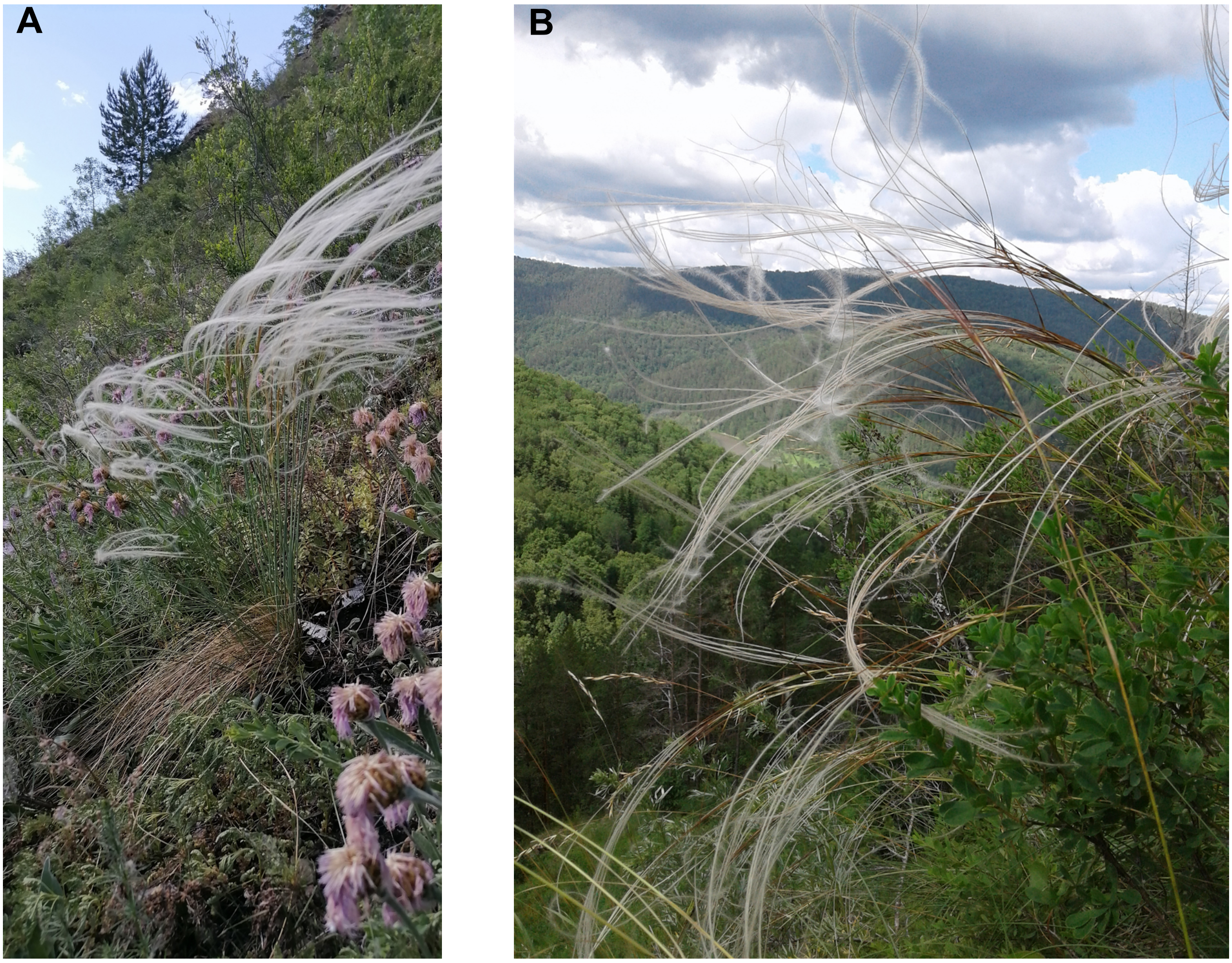

Fig. 1. General appearance of *S. pennata* in the Malyi Yamantau (**A**) and Bashkirskaya Skala (**B**) coenopopulations.

the awns of inflorescences reached the maximum length and clearly distinguishable pinnation. The onset of flowering has been observed in late May – early June. Two-factor MANOVA has been applied to assess the influence of meteorological indicators of the year and edaphic conditions of the coenopopulation ecotope on the morphometric parameters of *S. pennata*. In addition, correlation analysis has been applied for identifying a direct relationship between plant parameters and weather conditions. For small samples, Pearson's linear correlation coefficient ($r_{x,y}$) and Spearman's rank correlation coefficient were jointly applied. Microsoft Excel 2016 software package was used for calculations.

The characteristic of the ontogenetic states of European feather grass is given in the ontogenetic atlas (Serikova et al., 2013). The ontogenetic structure has been analyzed according to the well-known method (Zaugolnova et al., 1988). The leading population characteristics have been determined: the total population density and the age composition. According to the standard criteria, the following age states have been taken into account: seedlings (p), juvenile (j), immature (im), virginal (v), young generative (g_1), middle-age generative (g_2). In order to characterize the ontogenetic structure of coenopopulations, the recovery index (Ib) (Zhukova, 1995) and aging index (Ic) (Glotov, 1998) have been calculated. The criterion "delta-omega" has been applied to assess the CP state (Zhivotovsky, 2001). When studying the dynamics of age conditions in each coenopopulation, 30 sites have been randomly analyzed annually, where the number of individuals of all age groups has been counted per 1 m^2.

Results and discussion

Syntaxonomically, the studied coenopopulations grow in an association of steppe pine forests with an undergrowth of steppe shrubs **Ceraso fruticis – Pinetum sylvestris** Solomeshch et al. 2002 union **Caragano fruticis – Pinion sylvestris** Solomeshch et al. 2002 Class **Brachypodio pinnatae – Betuletea pendulae** Ermakov, Korolyuk et Lashchinsky 1991, confined to steep slopes of southern exposure along

Table 1. Dates of onset of phenological stages for *S. pennata* in the coenopopulations of the SUNR (Gorichev, 2015–2021). M is the average long-term phenological date, m is the error of the mean.

Years	Phenological phases					Meteorological indicators			
	Heading state	Bloom	Beginning of fruiting	Mature grains	Shedding the grains	The sum of average daily temperatures in May, °C	Number of rainy days	Precipitation in May, mm	Number of frosty days
2015	29.05	03.06	10.06	17.06	25.06	399.5	68	84.6	2
2016	07.05	02.05	27.05	01.06	17.06	407.4	55	23.5	6
2017	09.06	15.06	24.06	30.06	05.07	309.6	70	68.9	8
2018	05.06	08.06	1505	28.06	03.07	328.7	77	38.0	7
2021	03.05	11.5	19.05	25.05	30.06	525.5	26	11.0	2
M	**23.05**	**30.05**	**06.06**	**14.06**	**21.06**	**394.14**	**15.6**	**45.2**	**5**
m	**4.71**	**3.06**	**3.05**	**5.28**	**5.33**	**38.00**	**3.3**	**13.79**	1.26

river valleys composed of limestone and dolomite at 400–600 m altitude (Martynenko et al., 2008). Communities are formed on gravelly soddy humus-calcareous mountain-forest underdeveloped soils. A detailed botanical description of coenopopulation communities has been given in earlier publications (Yusupova and Abramova, 2016).

Dispersion analysis of the influence of a complex of ecotope conditions (position in the mesorelief, altitude, edaphic factors) and weather conditions of the growing season, as well as their combined effect on the morphometric parameters of plants *S. pennata* evidences that the characteristics of the ecotope affect some linear parameters of plants the most (32.44–83.53%): the leaf ligule length of the generative shoot, the ligule length of intra-sneath leaf, the panicle length, and the length of the bare twisted part of the awn (Table 2). Among the quantitative traits, the ecotope factor affects the number of awns in the inflorescence the most (26.76%). The weather factor predetermines the height of the generative shoot with panicle (44.12%) and the length of the 2nd intra-sneath leaf (41.70%). The parameters of European feather grass plants depend primarily on the edaphic conditions of the ecotope (MANOVA). The CP-1 occupies open steep, almost sheer coastal cliffs of southern exposure, facing the Malyi Inzer River, covered with sparse petrophytic vegetation. The CP-2 occupies the southern slope of a steep ridge, less often rocky slopes facing the stream valley, surrounded by a pine forest with an admixture of broad-leaved species. The opposite slope of the valley is covered by a dark coniferous forest. This ecotope is distinguished by more humid air, which accumulates in a narrow, damp stream valley, and a dense canopy of shrubs.

The combined effect of the two factors is weakly pronounced for plant height (29.09%). The maximum average values for many of the parameters are characteristic of CP-2, located in a shaded area with a relatively high projective cover of grasses and thickets of steppe shrubs. Plants of this coenopopulation have the greatest habitual parameters. Probably, the reason for this phenomenon is the dense population density of steppe shrubs, among which European feather grass grows. In order to enhance reproduction effectively, plants increase their habitus and enlarge panicles using their own resources and more favorable edaphic conditions than in CP-1. It is also possible that *Stipa pennata* in CP-2 adapt to growing conditions among overgrown shrubs by increasing the leaf blade of generative and vegetative shoots for more efficient photosynthesis. In CP-1, plants have largest number of generative and vegetative shoots. Forming dense turfs with an increased number of shoots is facilitated by the conditions of an open rocky weathered slope with intense solar radiation; in this way, plants adapt to dry growing conditions.

Weather conditions, in particular, the temperature regime and precipitation, affect the phenological rhythms of plants. The flowering of plants in 2016 and 2021 has started earlier than usual for the area (Table 1). The influence of weather conditions on morphometric parameters may be assessed by comparing the performance of plants by years with the amount of heat received (thermal resources) and the amount of precipitation by correlation analysis (Fig. 2). The Pearson and Spearman coefficients have been calculated for plant parameters that are most affected by weather conditions according to the analysis of variance, namely, the generative shoot height and the length of the 2nd intra-sneath leaf.

Table 2. The influence of a complex of environmental factors on the morphometric parameters of plants *S. pennata* in the coenopopulations of the SUNR. A – weather conditions of the year, B – conditions of the coenopopulation ecotope, AB – combined effect of these factors. The maxima are highlighted in bold, the minima, in italics. Asterisk* indicates the factor significance at $p < 0.001$, **– $p < 0.01$, *** – $p < 0.05$.

Parameters				General means by years						
	A	B	AB	2015	2016	2017	2018	2021	CP-1	CP-2
Number of generative shoots, pcs.	17.29**	9.64	8.11	6.10	6.36	**12.08**	*4.56*	9.44	**8.64**	6.76
Number of vegetative shoots, pcs.	4.25	19.40	11.45	20.10	20.42	*18.26*	**25.66**	22.98	**24.82**	18.14
Height of generative shoot with panicle, cm	**44.12****	3.49	**29.09****	81.15	81.37	**89.89**	88.66	*71.07*	83.73	**85.53**
Length of vegetative shoot with intra-sneath leaf, cm	23.57**	4.19	16.64**	41.76	42.33	*31.02*	**51.49**	39.33	40.09	**42.29**
Panicle length (inflorescence), cm	7.92	40.31*	8.03	43.09	**43.41**	41.61	43.21	*39.95*	40.31	**44.21**
Number of awns in the inflorescence, pcs	8.25	26.76**	3.43	**8.02**	7.86	7.66	6.78	*7.44*	**8.01**	7.09
Largest awn length, cm	5.18	9.56	2.94	33.61	34.11	32.73	**36.00**	*32.09*	32.72	**34.69**
Length of the bare twisted part of the awn, cm	10.33	**57.85***	15.09	*6.33*	6.37	7.87	**8.01**	6.67	**8.38**	5.72
Length of the hairs of the pinnate part of the spine, cm	3.98	1.09	3.11	0.46	0.46	0.44	*0.41*	**0.48**	0.45	0.45
Lower lemma length, cm	6.07	1.40	6.12	1.72	1.76	**1.82**	*1.67*	1.68	1.65	**1.73**
Glume length, cm	1.04	3.73	2.70	5.22	5.24	*5.09*	5.23	**5.27**	4.94	**5.48**
Leaf length (generative shoot), cm	16.30*	18.66*	10.60*	**10.81**	6.63	6.23	7.34	*5.26*	6.22	**8.29**
Leaf width (generative shoot), cm	12.49**	4.26	13.41**	*0.17*	0.22	0.19	0.19	**0.24**	0.20	**0.21**
Length of the 2nd intra-sneath sheet, cm	**41.70****	3.45	18.41**	19.76	20.02	32.27	**44.33**	*17.98*	25.91	**27.83**
Width of the 2nd sheet along the folded intra-sneath, cm	16.89*	**83.53***	17.43*	0.16	0.17	**0.21**	0.16	0.16	0.12	**0.22**
Straw diameter of generative shoot, cm	8.70	3.41	9.81	**0.25**	**0.25**	0.24	*0.20*	0.24	0.23	**0.24**
Length of leaf ligule of generative shoot, cm	10.61*	32.44*	13.86*	**0.28**	**0.28**	0.20	0.20	0.22	0.20	0.27
Length of ligule of the intra-sneath sheet, cm	9.26	32.58**	3.86	**0.17**	**0.17**	0.14	*0.11*	0.14	0.12	**0.17**
Number of nodes on the generative shoot, pcs.	1.60	1.12	1.19	2.16	2.20	**2.22**	2.14	*2.12*	2.16	**2.17**
Brush length of the intra-sneath sheet, cm	2.97	1.11	1.18	**0.22**	0.20	0.21	0.21	*0.20*	0.21	0.21

The value of the Pearson correlation coefficient between the height of the generative shoot and the amount of precipitation is 0.53, which corresponds to relatively tight relationship. This correlation is not statistically significant ($t_p < t_{crit.}$). There is a negative correlation between the sum of temperatures and plant parameters with a wide confidence interval: from −0.98 to 0.38 for the intra-sneath leaf length and from −0.97 to −0.99 for the shoot height. However, the Spearman test displays a positive, significant, and high correlation (0.42–0.95) between the plant parameters and weather factors (Table 3). The correlation between the morphometric parameters of plants and the amount of precipitation is statistically significant ($t_p > t_{crit.}$).

A positive correlation between the linear parameters of plants and the amount of precipitation is associated with a moisture deficit that occurs due to the fact that most of the precipitation in rocky slopes flows and evaporates without reaching the roots. Our results confirm this conclusion. The highest values for five or six out of the 20 analyzed parameters have been found in 2015, 2017 and 2018, which were characterized by rainy but relatively warm spring period during the plant flowering. On the contrary, the minimum values of factorial mean for six plant parameters have been observed in 2021 at the driest weather conditions; plant height and inflorescence length in this season have been noticeably smaller compared to other years. Therefore, we conclude that the amount of precipitation and the accompanying temperature regime have a direct effect on the parameters of European feather grass, thereby accelerating or slowing down its phenological development. In dry years, plants accelerate growth and development, while reducing habitual parameters, and vice versa, in the rainy period, plants slow down phenological rhythms, while maintaining optimal proportions.

Complete ontogenesis of a plant is a regular sequence of all stages of development of one generation or a number of generations of individuals (bionts) from the appearance of a diaspora to natural death as a result of aging. Each biont has its own particular ontogeny (Zhukova, 1983). An analysis of the ontogenetic structure of plants gives an idea of the stages of development of a population over a certain period of time. Information about the ontogenetic structure and demographic indicators of the studied populations of European feather grass are presented in Table 4.

The total population density of *S. pennata* varies from 4.1 to 6.4 ind./m^2. A higher population density of plants in CP-1 indicates more favorable conditions for the growth of European feather grass in CP-1 comparing to CP-2, where a high level of interspecific competition is manifested. It is possible that the absence of steppe shrubs also favorably affects the state of CP-1.

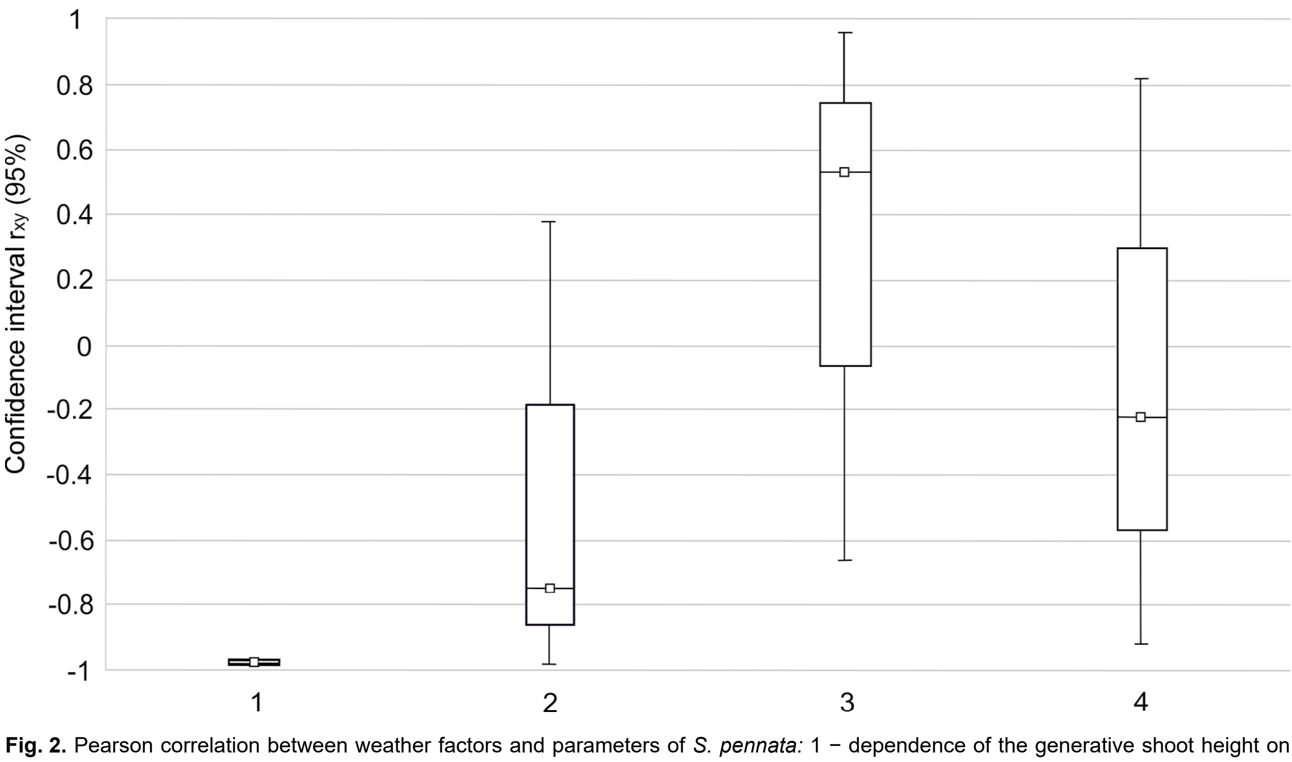

Fig. 2. Pearson correlation between weather factors and parameters of *S. pennata:* 1 − dependence of the generative shoot height on the sum of temperatures; 2 − dependence of the length of the 2nd intra-sneath sheet on the sum of temperatures; 3 − dependence of the generative shoot height on the amount of precipitation; 4 − dependence of the length of the 2nd intra-sneath sheet on the amount of precipitation.

Table 3. Pearson and Spearman's correlation coefficients for the factors (sum of average daily air temperatures and precipitation) and plant parameters (height of generative shoot and length of the 2nd intra-sneath sheet): $r_{x,y}$ – Pearson's linear correlation coefficient; r_s – Spearman's rank correlation coefficient; n – sample size; z – Fisher's test; se_z – standard error z; c_y – standard normal distribution quantile; z_l – lower bound of z; z_u – upper bound of z; r_l – lower bound of r; r_u – upper bound of r; t_p – *t*-value of the Student's *t*-test at $p = 0.05$ for the Pearson coefficient' t_s – *t*-value of the Student's *t*-test at $p = 0.05$ for the Spearman coefficient.

Indicators	Sum of average daily air temperatures, °C		Precipitation, mm	
	Height of generative shoot	Length of the 2nd intra-sneath sheet	Height of generative shoot	Length of the 2nd intra-sneath sheet
$r_{x,y}$	−0.99	−0.75	0.53	−0.22
t_p	−17.28	−1.99	1.08	−0.39
r_s	**0.42**	**0.64**	**0.95**	**0.94**
t_s	0.80	1.44	**5.49**	**4.68**
n	5	5	5	5
z	−3.44	−0.98	0.59	−0.22
se_z	0.71	0.71	0.71	0.71
c_y	1.96	1.96	1.96	1.96
z_l	−4.83	−2.37	−0.79	−1.61
z_u	−2.06	0.40	1.98	1.16
r_l	−0.99	−0.98	−0.67	−0.92
r_u	−0.97	0.38	0.96	0.82

Table 4. Averaged ontogenetic structure and demographic indicators of *S. pennata* coenopolulations.

CP	Population density, ind./m²	Ontogenetic state, %						Demographics				
		p	j	im	v	g_1	g_2	Δ	ω	CP type	$I_в$	$I_{ст}$
1	6.4	7.4	17.4	16.4	17.8	13	33	0.22	0.52	Young	2.58	0.00
2	4.1	12.2	13	11.6	15.8	16	24	0.21	0.51	Young	2.46	0.00

According to A.A. Uranov and O.V. Smirnova (1969), *S. pennata* populations are classified as normal incomplete in both study areas. The age spectra include plants of most age conditions, except for old generative and senile plants (Fig. 3). The age structure of the CP has a right-shifted unimodal spectrum type with a predominance of middle-aged plants (29–50%). European feather grass is renewed by seeds, so it is obvious that the self-maintenance of coenopopulations is carried out at the expense of generative plants. In CP-2, the proportion of seedlings is almost twice as high than in CP-1. The relatively high projective cover of grasses and shrubs creates a canopy, due to which moisture is retained on the soil longer and shading is observed, which favors the emergence of seedlings.

The ontogenetic state of plants reached the highest indicators in 2015 with a warm rainy spring period.

Such demographic indicators, as age Δ (delta) and efficiency ω (omega), evidence that both coenopopulations are young (Δ = 0.21–0.22; ω = 0.51–0.52). The recovery index ranges from 2.46 to 2.58, which indicates a good recruitment of young individuals and the predominance of the pre-generative fraction. The aging index is equal to zero, which is probably due to the young age of coenopopulations or the intensive death of old generative individuals.

The plant communities that include *S. pennata* are a transitional type of vegetation: stony steppes – real steppes – meadow steppes – thickets of steppe shrubs. Rubble and dryness of the substrate, erosion of main soils, and a peculiar microclimate create unfavorable conditions for the growth of trees and contribute to the maintenance of stony steppes, as a result of which the competitiveness of petrophytic-steppe groups increases. Along the entire area of

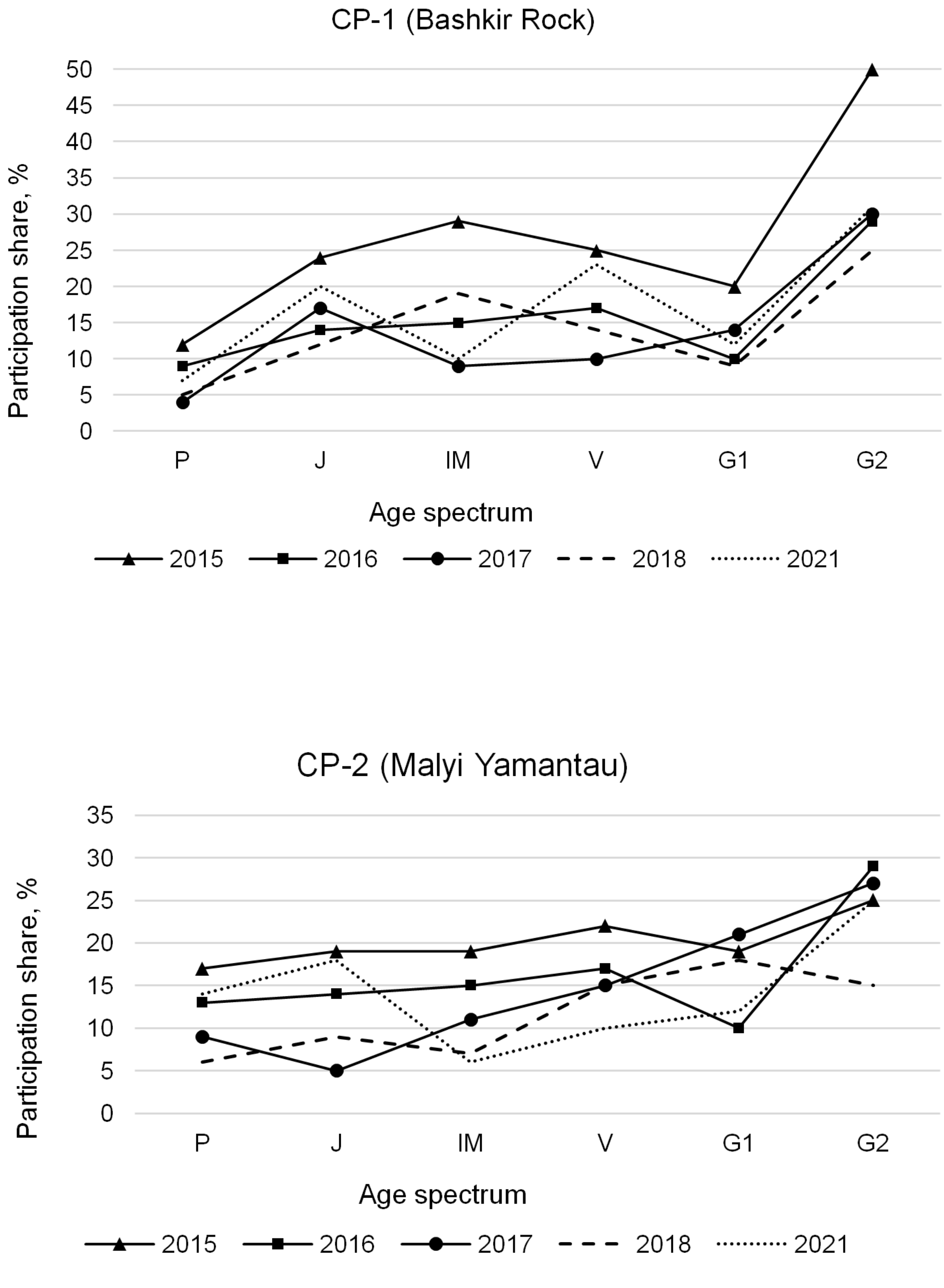

Fig. 3. Ontogenetic spectrum in *S. pennata* coenopopulations.

the studied rocks, European feather grasses are found mainly in real steppes and rarely play the key role or being an edificator species, as observed in the steppes of the Ilmensky Reserve or in typical European feather grass steppes, for example, in the Saratov and Kursk regions (Filatova, 2010; Polyanskaya and Suleymanova, 2019; Zolotareva, 2000; Zolotukhin et al., 2017). In addition, there is a process of overgrowing of real steppes on gentle slopes with competitive grasses and steppe shrubs due to the accumulation of fine soils in these areas. As noted by many authors, the presence of shrubs in communities is an indicator of an increase in the thickness of the fine soil layer and an improvement in soil moisture supply (Romakhina, 1965; Sochava, 1945). According to P.L. Gorchakovsky (1969, 2000), the appearance of European feather grass in the island mountain steppes of the Southern Urals is associated with the thermal maximum of the second half of the Middle Holocene, which has led to the invasion and dominance of steppe plants in phytocenoses, have a wide range in the steppes of Eurasia. Due to the formation of dense turfs on underdeveloped thin soils, European feather grass withstands competition from vegetatively mobile species.

Conclusions

Feather grass is extremely rare in the South Ural Nature Reserve. In the conditions of forest landscapes, *Stipa pennata* settle on rocky and steep slopes with thin, poorly developed soils, occupied by petrophytic-steppe groups.

Only two habitats of the species have been identified so far. Mesoclimatic conditions of ecotopes occupied by *S. pennata* are close as possible to the conditions of the steppe zone. In the two studied coenopopulations of *S. pennata,* phenotypic indicators of plants are similar with a slight difference in habitual and quantitative parameters. CP-2 plants are taller and larger, reflecting more favorable edaphic conditions. Plants of CP-1 under arid conditions are characterized by an increased number of generative and vegetative shoots. Perhaps due to the turfs, the plants ensure their high competitiveness with vegetatively mobile species. Dispersion analysis of the dynamics of plant parameters over five-year period indicates a high relationship between the state of coenopopulations and the conditions of the ecotope, primarily edaphic. The relationship between individual plant parameters and weather conditions is manifested to a lesser extent. According to correlation analysis, the linear parameters of plants in coenopopulations depend on the amount of incoming precipitation. The drier the growing season, the lower the plant parameters and the earlier their flowering, as confirmed by multi-year observations. On the contrary, the morphometric parameters of plants reach the highest values in rainy periods with a shift in the timing of flowering to a later time.

The population density and age range of plants reflect rather high population indices of European feather grass in both coenopopulations. The high occurrence of seedlings and young vegetative plants in both coenopopulations ensures self-maintenance of coenopopulations at a good level. The low proportion of old generative and senile plants confirms the young age state of coenopopulations. CP-2 has higher rates of seed germination, which indicates more favorable edaphic conditions of the ecotope. In CP-1, a high population density of individuals is observed, excluding seedlings. The xeromorphic features of the structure of European feather grass as typically steppe species, especially their narrow, longitudinally folded vegetative leaves, contribute to a decrease in transpiration under conditions of a well-heated slope during the period of active vegetation. Due to the high level of adaptation of plants to the contrasting conditions that occur on the rocks, the European feather grass withstands the extreme mesoclimatic and edaphic conditions of these ecotopes.

Therefore, based on the analysis of phenotypic and demographic indicators of *S. pennata* over a 5-year period, we state that the studied coenopopulations are young, and the conditions of the ecotopes occupied by the coenopopulations are favorable for the species success.

However, in general, the state of the species on the territory of the reserve may be assessed as critical. The coenopopulations of the species are small, scattered (isolates), separated by considerable distances; in addition, they occupy a narrow range of extremely dry and warm ecotopes (rocky slopes with sparse petrophytic vegetation). As bushes overgrow the European feather grass, the state of the these coenopopulations is steadily deteriorating.

Funding

The work has been carried out within the State Task for South Ural State Nature Reserve, no. 051-00084-22-00 (“Chronicle of Nature”), and the State Task for South-Ural Botanical Garden-Institute, Ufa Federal Research Center, no. 075-03-2022-001 (“Biodiversity of Natural Systems and Plant Resources of Russia: Assessment of the State and Monitoring of Dynamics, Problems of Conservation, Reproduction, Increase and Rational Use”.

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Финансирование

Работа выполнена по теме ЮУГПЗ «Летопись природы» в рамках государственного задания на 2022 г. № 051-00084-22-00 и по теме ЮУБСИ УФИЦ РАН «Биоразнообразие природных систем и растительные ресурсы России: оценка состояния и мониторинг динамики, проблемы сохранения, воспроизводства, увеличения и рационального использования» в рамках государственного задания на 2022 г. УФИЦ РАН №075-03-2022-001.

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